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# A simple classification system was recommended for patients with restricted shoulder or neck range of motion

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## Abstract

**Objective:** To construct an empirical classification of patients with shoulder complaints, and then to investigate the relationship between the empirical classification and the setting in which the patients were recruited, their demographic and clinical characteristics, and the original diagnostic categories.

**Study Design and Setting:** A latent class analysis was performed on the combined data of two previous studies.

**Results:** Four clusters of patients emerged, one with patients who have a small chance of any restriction of the motion of the shoulder and a moderate chance of restriction of the motions of the neck, a second with patients who have a high chance of restriction of the motions of the shoulder and a moderate chance of restriction of motions of the neck, a third with patients who have a low to moderate chance of restriction of all motions, and a fourth with patients who have a high chance of restriction of all of the motions. Patients recruited from a clinic for rheumatology and rehabilitation and from the orthopedic clinic were more present in the second cluster. Patients in the third cluster were on average younger than those in the other clusters. There appeared to be little agreement between the clusters found and the classification of patients according to the original diagnostic categories.

**Conclusion:** Patients experiencing shoulder pain can be classified in a simple way into four categories, reflecting the distinction between problems of the shoulder and those of the neck. A simple classification rule is proposed with which almost all patients can be classified into the four clusters. © 2006 Elsevier Inc. All rights reserved.

**Keywords:** Shoulder complaints; Diagnosis; Latent class analysis; Cluster analysis; Family practice

## 1. Introduction

In his *Textbook of Orthopaedic Medicine*, Cyriax [1] wrote with respect to shoulder complaints that “nearly all lesions of the joint and of adjacent soft tissues are tractable and, once relieved, seldom recur.” According to Cyriax, there are 12 tests that will enable any doctor to diagnose all shoulder complaints. The first Dutch National Guidelines on the diagnosis and management of shoulder complaints in general practice, issued in 1990, were largely based on the system proposed by Cyriax.

A number of studies conducted since the early 1990s show that there is doubt about the reliability shoulder

complaints diagnosis [2–4]. Only one study reports a high intraobserver reliability using the Cyriax classification of shoulder disorders [5]. There is a lack of consensus on the appropriate diagnostic criteria, exacerbated by the numerous diagnostic classifications of shoulder complaints that have been proposed [6–8]. These are all a priori classifications (based on expert opinion) that lack an empirical validation and are not always mutually exclusive. An attempt to resolve this lack of exclusivity was made in the first Dutch National Guidelines, by the introduction of two extra categories, “rest group” and “mixed clinical picture.” This attempt failed, however: too great a number of patients were categorized into these extra categories because clinical findings are not clearly attributable to one single diagnostic category [4] and, further, many practitioners considered the Cyriax classification too complex [9]. In 1999, therefore, the Dutch College of General Practitioners in 1999 changed the National Guidelines for

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Shoulder Complaints in favor of a less complicated classification [10].

This classification dilemma has led authors to question the usefulness of a diagnostic classification system for the treatment of patients with shoulder complaints [11,12].

A number of patients consulting a general practitioner with shoulder pain, may in fact have a disorder of the cervical spine rather than a disorder of the shoulder joint [8,13]. Sobel et al. [14] reported that 20% of the patients who presented to their general practitioner with shoulder complaints had no functional disorder of the glenohumeral joint, but additional examination revealed a disorder of the cervicothoracic spine.

The options available to the general practitioner for the treatment of shoulder complaints are limited: treatment with a nonsteroidal antiinflammatory drug, physiotherapy, manipulative therapy, or steroid injection into the shoulder joint. It seems only logical to reserve treatment with steroid injections to those patients with shoulder complaints who have disorders of the glenohumeral joint and not to patients with a disorder of the cervicothoracic spine. It is therefore important to explore the development of a classification (and preferably a simple classification) of patients with shoulder complaints that might be useful for the purpose of treatment selection.

Only a few studies have sought to create a classification of shoulder complaints on an empirical basis. De Jongh [15] reported two major clusters of patients using a method of hierarchical cluster analysis. One cluster of patients was characterized by restriction in the range of motion; the second cluster consisted of patients who showed little restriction in the range of shoulder motion but still experienced pain. Winters et al. [16] used a similar analysis and reported three clusters of patients: one cluster of patients with long-term complaints but hardly any restriction in the range of motion, a second cluster of patients with long-term complaints but with slight to average restriction in the range of motion, and a third cluster of patients with recent complaints and average to serious restrictions. Although both studies show that distinct groups of patients can be found, the distinctions between the groups they report do not reflect the classifications described earlier in the literature.

Groenier et al. [17] used multidimensional scaling to show that the clusters found by Winters et al. [16] could be represented on a single dimension reflecting merely the severity of the shoulder complaints. Multidimensional scaling of De Winter's original data [13] in which patients with neck complaints were also included in the analysis resulted in a two-dimensional structure [18]. One dimension corresponded with the severity of the restriction in the range of motion of the shoulder; the second dimension reflected the severity of the restriction in the range of motion of the cervical spine. Most patients were characterized by one or more restrictions of the motion of the shoulder as well as the neck. Furthermore, restriction in the active motions and passive motions, as well as the amount of pain

experienced by the patients when performing these motions, contributed to the results of the analysis in the same way. This suggests that it is sufficient to examine either the restriction in the passive or active motions, or the amount of pain. This suggestion is supported by a number of questionnaire development studies, where it has been deemed sufficient to record the amount of pain experienced by patients with shoulder complaints during performance of different activities in order to measure (perceived) recovery [19–23].

To select the appropriate therapy for individual patients, it is important to classify patients into distinct diagnostic groups rather than simply characterizing patients by scores on continuous scales, as is the case in multidimensional scaling.

For the present study we proposed three stages. First, we would analyze the combined data of the study of De Winter [13] and Winters et al. [24], to investigate the development of an empirical classification system of patients with shoulder or neck complaints (or both), based on the restriction in the range of motion (ROM). Next, we would compare the results of our empirical classification system with the original diagnostic categories used by De Winter [13] and Winters et al. [24]. Finally, we would explore the relationship between the results of our classification system with demographic and clinical characteristics of the patients, such as duration of complaints and patient-perceived pain.

## 2. Patients and methods

### 2.1. Patients

Our patients came from two sources. One source was the study by De Winter [13], in which 201 consecutive patients with shoulder complaints from general practice, orthopedic practice, and a clinic for rheumatology and rehabilitation were included. Patients with shoulder complaints that might be due to neck disorders also participated in the study. All patients were between 18 and 75 years old. Patients with shoulder problems due to neurological, vascular or internal disorders, systemic rheumatic diseases, fractures, or dislocations were excluded.

Our second source was the study by Winters et al. [24], in which 198 consecutive patients with shoulder complaints seeking consultation in seven general practices in a 1-year period starting in September 1994 were included. From this study, we used the data of 194 patients; four patients had missing data for one or more variables. Patients with shoulder complaints that might be due to neck disorders were also included. All patients were between 18 and 82 years old. Exclusion criteria were treatment for shoulder complaints in the 6 months prior to consultation, bilateral shoulder complaints, the presence of specific rheumatic disorders, shoulder complaints due to acute severe trauma (patients with a history of a distortion were not excluded), presence of cervical disk herniation, extrinsic shoulder complaints resulting

due to an internal disease, presence of dementia or other psychiatric disorders, and refusal to participate in the study.

## 2.2. Variables used in the construction of the classification

The variables indicating the passive restriction in the ROM from both studies were used to construct the classification. From the De Winter study [13], the following variables measuring the restriction in the ROM were used:

1. The degree of restriction in the ROM of the shoulder relative to the unaffected side: passive abduction, passive external rotation, passive medial rotation, and passive horizontal adduction. These variables were estimated by the investigator on a continuous scale in degrees. For analysis in the present study the variables were dichotomized: no restriction present was recorded when the range of motion was restricted less than 5° relative to the affected side, all other values were recorded as restricted.
2. The presence or absence of restriction in the ROM of the neck (to one or both sides): anteflexion, extension, rotation, and lateroflexion. These variables were scored on a dichotomous scale.

From the study by Winters et al. [24] the following variables measuring the restrictions of the ROM were used:

1. The restriction in the ROM of the shoulder relative to the unaffected side: passive abduction, passive external rotation, passive medial rotation, and passive horizontal adduction.
2. The restriction in the ROM of the neck (to one or both sides): anteflexion, extension, rotation, and lateroflexion.

All variables were originally scored on a four-point scale by the participating investigators. A score of 1 indicated a restriction in the range of motion by  $<5^\circ$  and was for the purpose of the present study recorded as no restriction present; a score  $>1$  was recorded as restricted.

Excluded from the analysis were the following measurements of the restriction in the ROM of the neck: rotation in extension and rotation in anteflexion, because these motions were not observed in the study by De Winter [13]. In both studies, the physical examination was performed according to the Dutch National Guidelines on the diagnosis and management of shoulder complaints [10].

## 2.3. Demographic variables and clinical characteristics

Demographic variables and clinical characteristics included (a) the setting from which the patients were recruited (general practice, orthopedic practice, or a clinic for rheumatology and rehabilitation); (b) age and gender of the patients; (c) duration of the complaint, in weeks; and (d) presence or absence of pain when assessing the

restrictions in the motions of the shoulder and neck. For patients in the study by De Winter [13], pain was as measured on the Shoulder Disability Questionnaire (SDQ); for patients in the study by Winters et al. [24], the pain score from a 7-item questionnaire developed earlier [22] was used. Both questionnaires are patient-perceived questionnaires.

## 2.4. Statistical analysis

The selected dichotomized variables from the pooled data were subjected to a latent class analysis [25,26] using Latent Gold [27] and WinMira 2001 [28] computer programs.

Latent class analysis (LCA) is a method with which one tries to explain the relationships between observed variables by a number of mutually exclusive latent classes (also called clusters). The most important characteristic of the method is that the relationship between the observed variables is determined solely by the fact that patients belong to different classes. As a consequence, the observed variables will be independent of each other for all patients belonging to a specific class. This condition is called “local independence” [25].

The following hypothetical example may help explain the idea of local independence. Suppose we have 250 patients, of whom 125 have a restriction in the passive abduction of the shoulder (*A*) and 160 patients have a restriction in the lateral flexion of the neck (*B*). The relationship between these two variables *A* and *B* could be as is depicted in Table 1. There is a highly significant relationship between the two variables, as can be seen from the results of the  $\chi^2$  test ( $\chi^2 = 6.9$ ,  $df = 1$ ,  $P = .008$ ). Suppose further that this relationship can be explained completely by two latent classes (indicated by the latent variable *C*). The relationship within each of the two classes will be as in Table 2, resulting in a  $\chi^2 = 0.0$  in each of both cross-tabulations. So within each of the two classes restriction in the passive abduction of the shoulder (*A*) is independent of restriction in the lateral flexion of the neck (*B*). In practice, there are of course more than two variables observed, and the aim of LCA is to find how many classes are needed (preferably a small number) to describe the relationships between these observed variables, and at the same time to determine which patients belong to a specific latent class.

Because LCA is probabilistic, patients are not deterministically assigned to a cluster, as would be done in other clustering techniques such as hierarchical cluster analysis or *k*-means clustering. For each patient, an estimate is given

Table 1  
Relationship between variables *A* and *B*

	Variable <i>B</i> +	Variable <i>B</i> –	Total
Variable <i>A</i> +	90	35	125
Variable <i>A</i> –	70	55	125
Total	160	90	250

Table 2  
Relationship between variables A and B for each level of latent variable C

	Latent variable C			
	Latent class 1		Latent class 2	
	Variable B +	Variable B –	Variable B +	Variable B –
Variable A +	80	20	10	15
Variable A –	40	10	30	45

of the probability that this patients belongs to each latent class. Subsequently, patients are assigned to the latent class that has the highest probability. In the case of clustering patients with shoulder complaints, it would be convenient if each patient has a high probability of belonging to a specific class and low probabilities of belonging to the other classes.

In general, one can state that the probability that a randomly selected patient will be located in one of the cells  $i, j, \dots, m, t$  of the cross-tabulation of the observed variables A, B, ..., E and the latent variable X can be expressed as

$$\pi_{ij\dots mt}^{AB\dots EX} = \pi_{it}^{\bar{A}X} \times \pi_{jt}^{\bar{B}X} \times \dots \times \pi_{mt}^{\bar{E}X} \times \pi_t^X,$$

the product of the conditional probabilities  $\pi_{it}^{\bar{A}X}$ ,  $\pi_{jt}^{\bar{B}X}$ , and so on, and the probability that the patient belongs to a particular class  $t$  of  $X$ —that is,  $\pi_t^X$  [26]. So, all latent classes are characterized by the probability of a specific pattern of observed variables expressed by the conditional probabilities.

In practice one starts with only one latent class, which would indicate that all variables are independent of each other. From this latent class one predicts the pattern of responses of the patients on the observed variables. The fit between these predicted responses based on the latent classes and the observed pattern is used as a criterion to measure the success of the approach. The number of latent classes is increased until the fit between the predicted and observed data is satisfactory. The  $\chi^2$  test is used as a measure of fit. As long as there is a significant  $\chi^2$ , the number of classes is increased until the test no longer shows

a significant  $P$ -value. We used the Latent Gold program for the analysis of the data.

Note that a complication in determining the fit arises when the number of observed variables is large with respect to the number of observations. The use of a so-called bootstrap procedure then is recommended for evaluating the fit of the results [29]. The computer program WinMira 2001 [28] incorporates such a bootstrap procedure and was used to evaluate the fit of the results.

Given the results of previous studies [16–18] the expected number of classes will be at least three.

Because the most important assumption in LCA is the concept of local independence, only restriction in passive motions was used in the present study. It is highly unlikely that within each latent class restriction in active motions will be independent of restriction in passive motions. For the same reason, the amount of pain experienced with the motions was omitted from the analysis.

Relationships between class membership and demographic and clinical data and original diagnostic categories were examined with the use of analysis of variance (ANOVA) or nonparametric tests (when dependent variables violate the normality assumption) and the  $\chi^2$  test. The relationships with the patient-perceived questionnaires were analyzed separately for each study. The scales of both questionnaires were transformed into z-scores (mean of zero and standard deviation of one) to facilitate comparison.

Statistically significant differences between the classes were examined. A difference was considered statistically significant at  $P < .05$ .

3. Results

Patient characteristics for both of the included studies are given in Table 3. For the study by De Winter [13], patient characteristics are given for each setting. The most striking difference between the two studies was in the duration of complaints.

Table 3  
Demographic and clinical characteristics of patients according to setting

Variable	De Winter [13]				Winters et al. [24]
	General practice	Orthopedic practice	Clinic for rheumatology and rehabilitation	Total	General practice
Sample size	$n = 75$	$n = 33$	$n = 93$	$n = 201$	$n = 194$
Percentage female	67	52	70	63	56
Mean age in years (SD)	43.9 (13.0)	48.6 (10.6)	50.2 (10.9)	47.6 (12.0)	48.3 (15.4)
Percentage dominant shoulder affected	59	68	46	57	59
Percentage problems on both sides	21	6	39	27	Excluded
Percentage previous episodes of shoulder pain	40	30	43	40	43
Median duration of current episode in weeks (P25, P75)	18 (9, 53)	53 (25, 55)	42 (22, 55)	36 (13, 54)	4.0 (1.0, 26.5)
Mean total pain score (SD)	62.8 (25.5) <sup>a</sup>	60.7 (24.3) <sup>a</sup>	75.4 (19.1) <sup>a</sup>	68.2 (23.4) <sup>a</sup>	11.7 (4.3) <sup>b</sup>

Abbreviations: Pnn, percentile; SD, standard deviation.  
<sup>a</sup> Pain is measured on a scale from 0 (no pain at all) to 100 (severe pain).  
<sup>b</sup> Pain is measured on a scale from 0 (no pain at all) to 21 (severe pain).



### 3.1. LCA

The LCA resulted in four clusters of patients ( $\chi^2 = 272.4$ ,  $df = 220$ ,  $P = .09$ ,  $\chi^2$  test). Figure 1 shows the percentage of positive responses for all variables in each cluster.

Cluster 1 contains about one third (33.6%) of the patients. Only a moderate number of these patients (between 10% and 36%) showed restriction in the ROM of the shoulder and of extension and anteﬂexion of the neck. Restriction in lateroﬂexion and rotation of the neck was present in more than half of these patients (56% and 67%).

Cluster 2 also contains about a third of the patients (32.1%). The majority of those patients showed a restriction in the ROM of the shoulder (82% to 91%) and a substantial number of the patients in cluster 2 had a restriction in lateroﬂexion and rotation of the neck (63% and 40%).

Cluster 3 contains about a quarter of the patients (25.6%). Only medial rotation of the shoulder and horizontal adduction were limited in a substantial number of these patients (48% and 38%); all other motions were found to be restricted in only a very small number of patients (between almost no one and 22%).

Cluster 4 contains the remaining 8.7% of the patients. Almost every patient in this cluster experienced a restriction in all motions, from the shoulder as well from the neck (from 64% in the case of anteﬂexion of the neck to >99% in the case of medial rotation of the shoulder).

### 3.2. Relationship between clusters and the clinical characteristics and demographic variables

Figure 2 shows the percentages of positive responses for all pain variables for each cluster. The pattern of percentages of positive responses for each cluster matches that of the responses for the restriction in the ROM. This means

that for each cluster there is a clear relationship between the restriction in a motion and the pain experienced while performing the particular motion.

Table 4 shows the distribution of the patients among the various settings from which the patients were recruited. Patients from the orthopedic clinic and the rehabilitation center are relatively more present in cluster 2. Patients from general practice are more present in cluster 3 and 4 for the study by De Winter [13], and those from the study by Winters et al. [24] are more present in cluster 1 and less in cluster 4 ( $P < .0005$ ,  $\chi^2$  test).

From Fig. 3, it is clear that the mean age of patients belonging to cluster 3 is lower than that of patients belonging to the other clusters ( $P < .0005$ , one-way ANOVA with Bonferroni correction). There appeared to be no significant difference in the duration of complaints between the different clusters ( $P = .53$ , Kruskal–Wallis test).

In Fig. 4, the relationship between cluster membership and the score on the Shoulder Disability Questionnaire (SDQ) and the pain score from the study by Winters et al. [24] is shown for each study. The patients from the study by De Winter [13] belonging to cluster 3 show less discomfort on average than those belonging to the other clusters ( $P < .0005$ , one-way ANOVA).

On the other hand patients from the study by Winters et al. [24] belonging to cluster 1 show less pain on the average than those belonging to the other clusters ( $P = .001$ , one-way ANOVA).

In the study by De Winter [13], patients were diagnosed using the guidelines of Cyriax. The relationship of the diagnosis and cluster membership is presented in Table 5. Most of the patients (80.4%) diagnosed as having a capsular syndrome belong to cluster 2. Acute bursitis and acromioclavicular syndrome were hardly ever diagnosed, and the

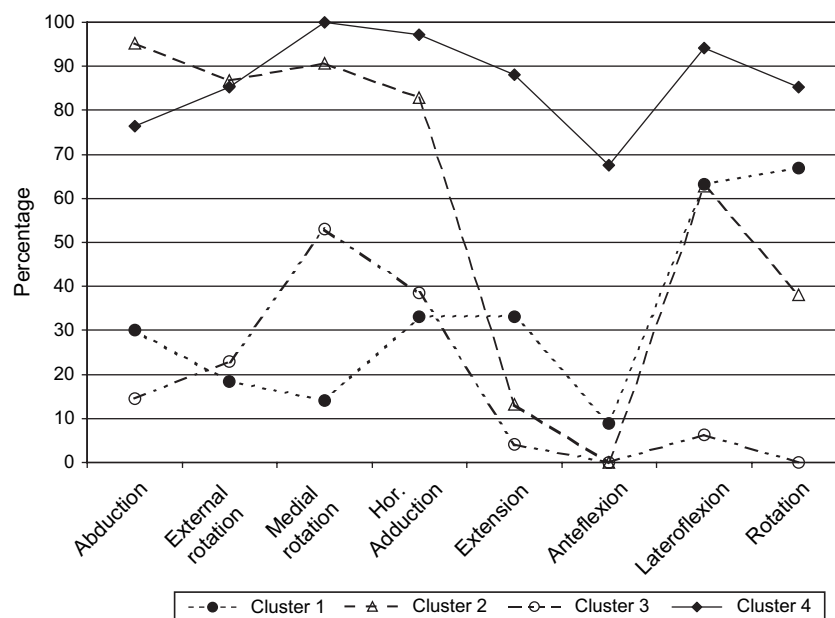


Fig. 1. Percentage of patients in each cluster experiencing restrictions in motions of shoulder and neck. Hor., horizontal.

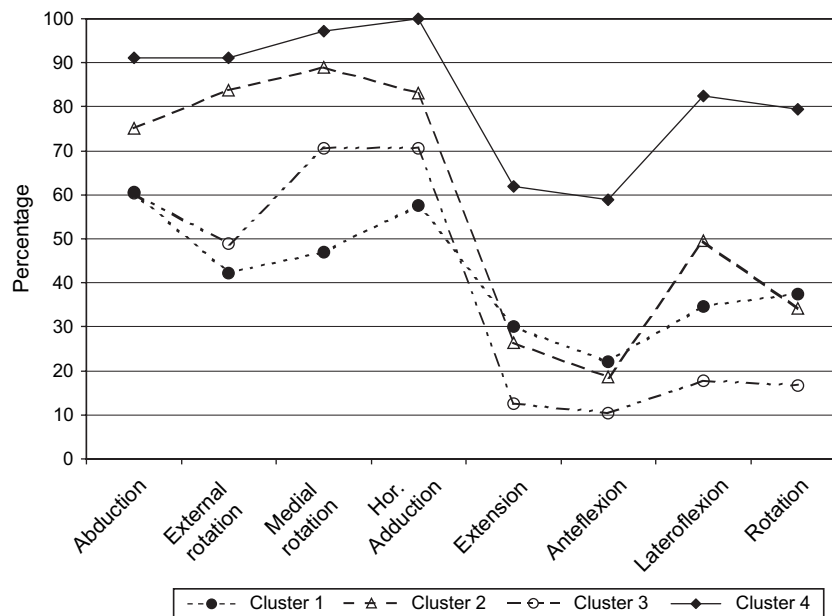


Fig. 2. Percentage of patients in each cluster experiencing pain with motions of shoulder and neck. Hor., horizontal.

other diagnoses did not show a clear-cut relationship with cluster membership.

In the study by Winters et al. [24], patients were diagnosed into three groups, one group having shoulder complaints of a synovial nature (disorders of the joint capsule or the synovial cavity of the humeroscapular joint, the subacromial cavity, or the acromioclavicular joint, singly or in combination), one with complaints originating from the shoulder girdle (no disorders in the synovial structures but functional disorders in the shoulder girdle, consisting of the cervical spine, the upper thoracic spine and the adjoining ribs), and a third group with a combination of these two diagnoses. The relationship of this classification and cluster membership is shown in Table 6 ( $\lambda = 0.13$ ). About three quarters of the patients diagnosed with problems from the shoulder girdle belong to cluster 1.

Based on the number of motions that are restricted, a scoring system was constructed to classify the patients in a simple way. First, two scores are constructed: the number of motions of the shoulder that are restricted (ranging from 0 to 4) and the number of the motions of the neck that are restricted (ranging from 0 to 4).

Patients in cluster 1 are characterized by both  $\leq 2$  restricted motions of the shoulder and  $\geq 1$  restricted motions of the neck. Patients in cluster 2 have both  $\geq 3$  restricted motions of the shoulder and  $\leq 2$  restricted motions of the neck. In cluster 3, the patients are characterized by both  $\leq 2$  restricted motions of the shoulder and 0 restricted motions of the neck. Patients in cluster 4 have  $\geq 3$  restricted motions of both the shoulder and the neck.

Table 7 presents the agreement between the classification based on the scoring system (predicted cluster membership) and the clusters from the LCA (observed cluster membership). The almost perfect agreement resulted in a coefficient  $\kappa = 0.90$ .

#### 4. Discussion

The results of the LCA show that a distinction can be made between patients with different types of restriction in the motions of the shoulder, neck, or both. Patients are clustered into four groups: those with a high probability of restriction in the motions of the neck and a low

Table 4  
Relationship between cluster membership and setting of patients

	De Winter [13]		Winters et al. [24]		Total
	Orthopedic clinic	Rehabilitation	General practice	General practice	
Cluster 1, no. (%)	8 (24)	25 (27)	14 (19%)	89 (46)	136 (34)
Cluster 2, no. (%)	17 (52)	42 (45)	18 (24)	52 (27)	129 (33)
Cluster 3, no. (%)	8 (24)	14 (15)	31 (41)	43 (22)	96 (24)
Cluster 4, no. (%)	0 (0)	12 (13)	12 (16)	10 (5)	34 (9)
Total	33 (8)	93 (24)	75 (19)	194 (49)	395

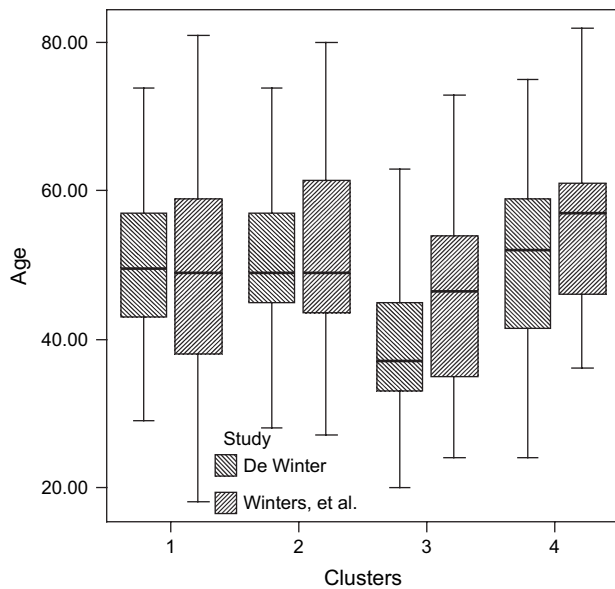


Fig. 3. Relationship between cluster membership and age of patients. References: De Winter [13]; Winters et al. [24].

probability of restriction in the motions of the shoulder (cluster 1), those with a low probability of restrictions in the motion of both the shoulder and the neck (cluster 3), those with a high probability of restrictions in the motion of the shoulder and a low to moderate probability of a restrictions in the motion of the neck (cluster 2), and finally a small group of those with a high probability of restriction in the motions of the shoulder as well as the neck (cluster 4). In clusters 1 through 3, only a small proportion of patients had difficulties with extension and anteflexion of the neck, whereas in cluster 4 a large proportion of patients had problems with these motions.

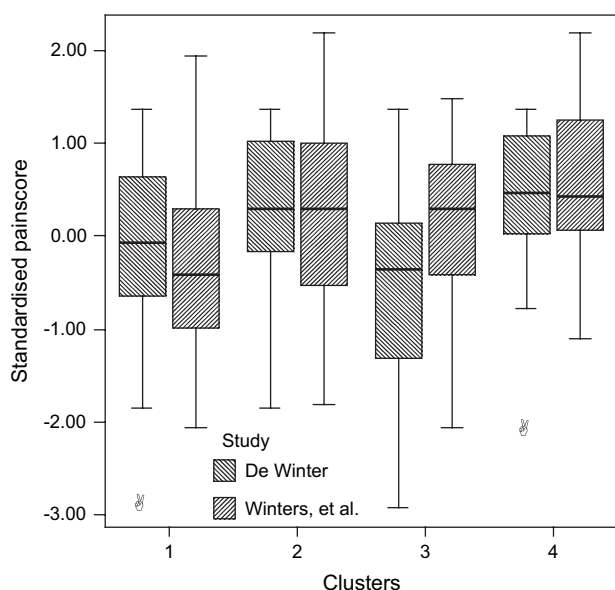


Fig. 4. Relationship between cluster membership and pain score. References: De Winter [13]; Winters et al. [24].

Table 5

Relationship between diagnosis following Cyriax guidelines and cluster membership in the De Winter study

Diagnosis	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Total
Capsular syndrome	2 (4)	37 (80)		7 (15)	46
Acute bursitis	1 (100)				1
Acromioclavicular syndrome	1 (14)	1 (14)	5 (71)		7
Subacromial syndrome	24 (30)	17 (21)	33 (41)	6 (8)	80
Rest group	14 (35)	10 (25)	9 (23)	7 (18)	40
Mixed clinical picture	4 (15)	12 (46)	6 (23)	4 (15)	26
Total	46 (23)	77 (38)	53 (26)	24 (12)	200

The results show further that patients can be classified into the four clusters based on only the number of restricted passive motions.

In studies by De Jongh [15] and Winters et al. [16], a group of patients was identified who had hardly any restriction in the motions of shoulder and neck although they reported shoulder pain. In the present study, this combination of complaints is found in cluster 3. Patients with severe restrictions, which were reported to be a small group in another study conducted by Winters et al. [16], were the same type as those found in cluster 4 in the present study. Winters et al. [24] made a diagnostic distinction only between problems in the synovial structures, problems from the shoulder girdle, and a combination of both in their research, but we could not establish a clear overall relationship with the clusters found in the present study; however, three quarters of the patients in the category “shoulder girdle” were assigned to cluster 1.

There was also an unclear relationship between the clusters we found and the diagnostic classification of De Winter [4], which was based on Cyriax’s ideas. Although nearly all of the patients with a capsular syndrome (80%) were categorized in cluster 2, the distribution of patients among the other clusters did not show a regular pattern. This of course could be expected, because in a priori classifications like the one proposed by Cyriax the presence of complaints such as pain and restriction in motion cannot in general be considered clear-cut indicators of specific disorders. A number of patients experience shoulder complaints without a functional disorder of the glenohumeral joint [14]. On the other hand, manifest disorders of the shoulder are often associated with multiple complaints, none of which represent a unique symptom of a particular disorder. According to De Winter [4], the unsatisfactory reproducibility reported in various studies might be explained by this phenomenon.

Table 6

Relationship between cluster membership and diagnosis in the study of Winters et al

Diagnosis	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Total
Synovial, no. (%)	24 (24)	39 (39)	32 (32)	4 (4)	99
Shoulder girdle, no. (%)	35 (76)	2 (4)	7 (15)	2 (4)	46
Combination, no. (%)	28 (62)	10 (22)	3 (7)	4 (9)	45
Total	87 (46)	51 (27)	42 (22)	10 (5)	190



Table 7  
Relationship between predicted and observed cluster membership

Predicted	Observed				Total
	Cluster 1	Cluster 2	Cluster 3	Cluster 3	
Cluster 1, no. (%)	<b>136 (88.9)</b>	5 (3.3)	10 (6.5)	2 (1.3)	153 (38.7)
Cluster 2, no. (%)		<b>123 (93.2)</b>	7 (5.3)	2 (1.5)	132 (33.4)
Cluster 3, no. (%)			<b>79 (100.0)</b>		79 (20.0)
Cluster 4, no. (%)		1 (3.2)		<b>30 (96.8)</b>	31 (7.8)
Total	136 (34.4)	129 (32.7)	96 (24.3)	34 (8.6)	395

Cohen's  $\kappa = .90$ .

In empirical classifications such as LCA, the approach is quite different. The results of our study show that the number of restricted motions is sufficient for the classification. The drawback of this approach, of course, is that the precise location of the disorder cannot be indicated. On the other hand, a number of studies [2,3,13] have shown that agreement between observers is low to only moderate—which is why traditional diagnosis fails. The interobserver agreement for the restriction in the motion of the neck in De Winter's study [13] ranged from 0.38 to 0.61 (Cohen's  $\kappa$ ) and for restriction in motion of the shoulder from 0.53 to 0.60. A simpler classification based on the number of restricted motions will be more reliable because the sum of the symptoms has a higher reliability than the individual items [18,30]. Furthermore, because it will be easier to reach a satisfactory level of agreement between observers in a simple classification system (one with only a few categories) than in a complex system with a large number of categories one would favor the simpler system. Moreover, there are only three or four effective therapies available to the general practitioner, so a more complex classification system is clearly unnecessary. Our proposed classification based on the LCA might indeed be useful in the allocation of patients to these available therapies. Unfortunately, we have no data to explore the effect of our proposed system on treatment decisions making or outcome, so we suggest the undertaking of further research to measure the efficacy of this simple diagnostic system.

Although there are differences between the diagnostic classification found in this study and those reported earlier [15–17], all empirical classifications show that only a few number of groups can be distinguished, regardless of the number of patient characteristics or dichotomized variables used in the analysis.

The patients in our analysis consulted their general practitioner with shoulder pain, but it appears that a number of them had complaints attributable to problems concentrated around the cervical spine. This supports the advice given by the Dutch National Guidelines, that physicians should examine the motion of the neck in patients with shoulder complaints.

Together with the results from the previous classification studies by Groenier et al. [15], Winters et al. [16], and

De Jongh [17], the present results support the decision of the Dutch College of General Practitioners to favor a simple classification in their National Guidelines for Shoulder Complaints.

Perhaps in matters of diagnosing patients with shoulder complaints there is much truth in the words attributed to the economist John Maynard Keynes: "I would rather be vaguely right, than precisely wrong."

## References

- [1] Cyriax J. Textbook of orthopaedic medicine. 7th ed. London: Bailliere Tindall; 1981.
- [2] Bamji AN, Erhardt CC, Price TR, Williams PL. The painful shoulder: can consultants agree? *Br J Rheumatol* 1996;35:1172–4.
- [3] Liesdek C, Wind Dvd, Koes BW, Bouter LM. Soft-tissue disorders of the shoulder: a study of the inter-observer agreement between general practitioners and physiotherapists and an overview of physiotherapeutic treatment. *Physiotherapy* 1997;83:12–7.
- [4] De Winter AF, Jans MP, Scholten RJ, Deville W, van Schaardenburg D, Bouter LM. Diagnostic classification of shoulder disorders: interobserver agreement and determinants of disagreement. *Ann Rheum Dis* 1999;58:272–7.
- [5] Pellicchia GL, Paolino J, Connell J. Intertester reliability of the Cyriax evaluation in assessing patients with shoulder pain. *J Orthop Sports Phys Ther* 1996;23:34–8.
- [6] Uthoff HK, Sarkar K. Classification and definition of tendinopathies. *Clin Sports Med* 1991;10:707–20.
- [7] Hedtmann A, Fett H. [So-called humero-scapular periartropathy: classification and analysis based on 1,266 cases]. In German. *Z Orthop* 1989;127:643–9.
- [8] Sobel JS, Winters JC, Groenier K, Arendzen JH, Meyboom DJ. Physical examination of the cervical spine and shoulder girdle in patients with shoulder complaints. *J Manipulative Physiol Ther* 1997;20:257–62.
- [9] Bakker JF, Bosch JHMvd. [Somatic aspects of vague shoulder complaints]. In Dutch. *Huisarts Wet* 1984;27:249–51.
- [10] Bakker JF, Jongh ACd, Jonquière M, et al. Schouderklachten. NHG Standaard M08 (National Guidelines for Shoulder Complaints of the Dutch College for General Practitioners). *Huisarts Wet* 1990;33:196–202.
- [11] Hay EM, Thomas E, Paterson SM, Dziedzic K, Croft PR. A pragmatic randomised controlled trial of local corticosteroid injection and physiotherapy for the treatment of new episodes of unilateral shoulder pain in primary care. *Ann Rheum Dis* 2003;62:394–9.
- [12] Smidt N, Green S. Is the diagnosis important for the treatment of patients with shoulder complaints? *Lancet* 2003;362:1867–8.
- [13] De Winter A. Diagnosis and classification of shoulder complaints. Vrije Universiteit Amsterdam; Doctoral dissertation: 1999.
- [14] Sobel JS, Winters JC, Groenier KH, Meyboom-de Jong B. [Shoulder complaints in general practice]. In Dutch. *Huisarts Wet* 1995;38:342–7.
- [15] Jongh Ad. Schouderklachten in de huisartspraktijk [Shoulder complaints in general practice]. In Dutch. Erasmus University Rotterdam; Doctoral dissertation: 1994.
- [16] Winters JC, Groenier KH, Sobel JS, Arendzen JH, Meyboom-de Jongh B. Classification of shoulder complaints in general practice by means of cluster analysis. *Arch Phys Med Rehabil* 1997;78:1369–74.
- [17] Groenier KH, Winters JC, Meyboom-de Jong B. Classification of shoulder complaints in general practice by means of nonmetric multidimensional scaling. *Arch Phys Med Rehabil* 2003;84:812–7.
- [18] Groenier KH, De Winter AF, Winters JC, de Vet HCW, Meyboom-de Jong B. Complaint-severity and cervical spine problems successfully classified patients with shoulder complaints. *J Clin Epidemiol* 2004;57:730–6.

- [19] van der Heijden GJ, Leffers P, Bouter LM. Shoulder disability questionnaire design and responsiveness of a functional status measure. *J Clin Epidemiol* 2000;53:29–38.
- [20] van der Windt DA, van der Heijden GJ, De Winter AF, Koes BW, Deville W, Bouter LM. The responsiveness of the Shoulder Disability Questionnaire. *Ann Rheum Dis* 1998;57:82–7.
- [21] Winters JC, Sobel JS, Groenier KH, Arendzen JH, Meyboom-de Jong B. The course of pain and the restriction of mobility in patients with shoulder complaints in general practice. *Rheumatol Int* 1997;16: 219–25.
- [22] Winters JC, Sobel JS, Groenier KH, Arendzen JH, Meyboom-de Jong B. A shoulder pain score: a comprehensive questionnaire for assessing pain in patients with shoulder complaints. *Scand J Rehabil Med* 1996;28:163–7.
- [23] van der Heijden GJMG. Shoulder disorders: a state-of-the-art review. *Best Pract Res Clin Rheumatol* 1999;13:287–309.
- [24] Winters JC, Sobel JS, Groenier KH, Arendzen JH, Meyboom-de Jong B. Comparison of physiotherapy, manipulation, and corticosteroid injection for treating shoulder complaints in general practice: randomised, single blind study. *BMJ* 1997;314:1320–5.
- [25] Lazarsfeld PF, Henry NW. Latent structure analysis. New York: Houghton Mifflin; 1968.
- [26] McCutcheon AL. Latent class analysis. Newbury Park, CA: Sage Publications; 1987.
- [27] Vermunt JK, Magidson J. Latent Gold user's guide. Belmont, MA: Statistical Innovations; 2000.
- [28] Davier V. M. WINMIRA: A Windows 3.x program for analysis with the Rasch model, with the latent class analysis, and with the mixed Rasch model. Kiel: Institute for Science Education; 1994.
- [29] Collins LM, Fidler PL, Wugalter SE, Long JD. Goodness-of-fit testing for latent class models. *Multivar Behav Res* 1993;28:375–89.
- [30] Nunnally JC. Psychometric theory. New York: McGraw-Hill; 1967.